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KIMBER'S CONSTRUCTIONS

VAUBAN'S FIRST SYSTEM

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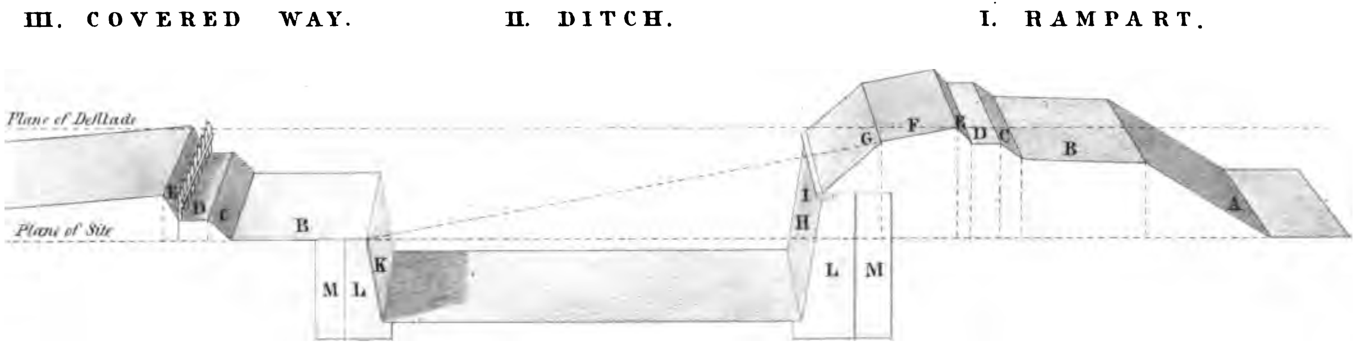
PERSPECTIVE PROFILE,

Shewing the three principal parts of every complete fortification and their subdivisions.



N.B. The letters of reference correspond to those in plate 2, and the explanation on page 16.

W. Monkhouse. Lith York.

CONSTRUCTION

OF

VAUBAN'S FIRST SYSTEM,

CONSISTING OF

SIX DRAWINGS

AS EXECUTED AT SANDHURST AND ADDISCOMBE;

WITH

INSTRUCTIONS

GIVING THE DIMENSIONS OF EVERY LINE AND ANGLE,

AND

REMARKS

On Plan-Drawing, Shading, and Colouring.

BY

THOMAS KIMBER, B.A.,

LATE OF KING'S COLLEGE, LONDON.

> "Vauban sur un rampart, un compas à la main,
> Rit du bruit impuissant de cent foudres d'arain."

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231. a. 31.

TO THE REV. W. G. HAWTAYNE, M. A.,

SOUTH ROW, BLACKHEATH.

Dear Sir,

I cannot inscribe this little introduction to an important department of Strategic Science to any one more appropriately than to you, who first drew my attention to the study of Fortification, and who have so efficiently guided your pupils in the same study.

I am,
Dear Sir,
Yours faithfully,
THOMAS KIMBER.

THE *origin* of this work is the same as that of most of its class:—the want of some such work was experienced in teaching; and oral instruction was found inefficient to convey all the necessary details, in cases where constant and immediate superintendence was impracticable.

Its *design* is entirely supplementary.

2, BOWATER PLACE, BLACKHEATH, Nov. 1850.

NOTICE.—The Plans numbered 1, 2, 3, 4, 5, and 6, are intended to be drawn on scales of half the number of yards and feet to the inch; that is to say, for every yard or foot in the scale attached to the drawing, two are to be taken for the copy, which will thus be four times the size of the original, and will fill a sheet of drawing paper of the ordinary size on which Plans are generally drawn.

A dash superscribed to a figure means feet; two dashes mean inches; and figures without any superscription stand for yards. For instance: 3, 4′, 5″, is read, 3 yards, 4 feet, 5 inches.

ERRATA.

Page 10, lines 3 and 5, for 26 read 260.
—— 13, first line, for *A B R* read *A B S*.
—— 13, line 7 from bottom, for 127° read 121°.
—— 19, line 7 from bottom, for *page* read *pages*.
—— 21, line 7, for *drawings* read *drawing*.
—— 22, last line, for *is* read *are*.
—— 26, last line, for *diagram* read *profiles*.
—— 27. line 9 from bottom, for *with* read *without*.

CONSTRUCTION

OF

VAUBAN'S FIRST SYSTEM.

THE fortified place is supposed to be surrounded by equal right lines forming the sides of a regular polygon, and one side of this polygon is the base of the construction. All the remaining lines and angles of the outline are determined from the length of this base, and the length of the base itself is determined by the range of the arms employed in the defence of the place.

The works constructed on each side are called a front of fortification. Outlines and plans of the first system, as generally drawn, contain two fronts.

The first step to be taken in drawing an outline or plan, is to determine the angle of the figure on which it is to be traced. This angle varies as the number of sides in the figure varies, and is found by (Euclid I. 32. Cor.) substracting from 180°, 360°, divided by the same number as there are sides to the figure.

Plate 1.

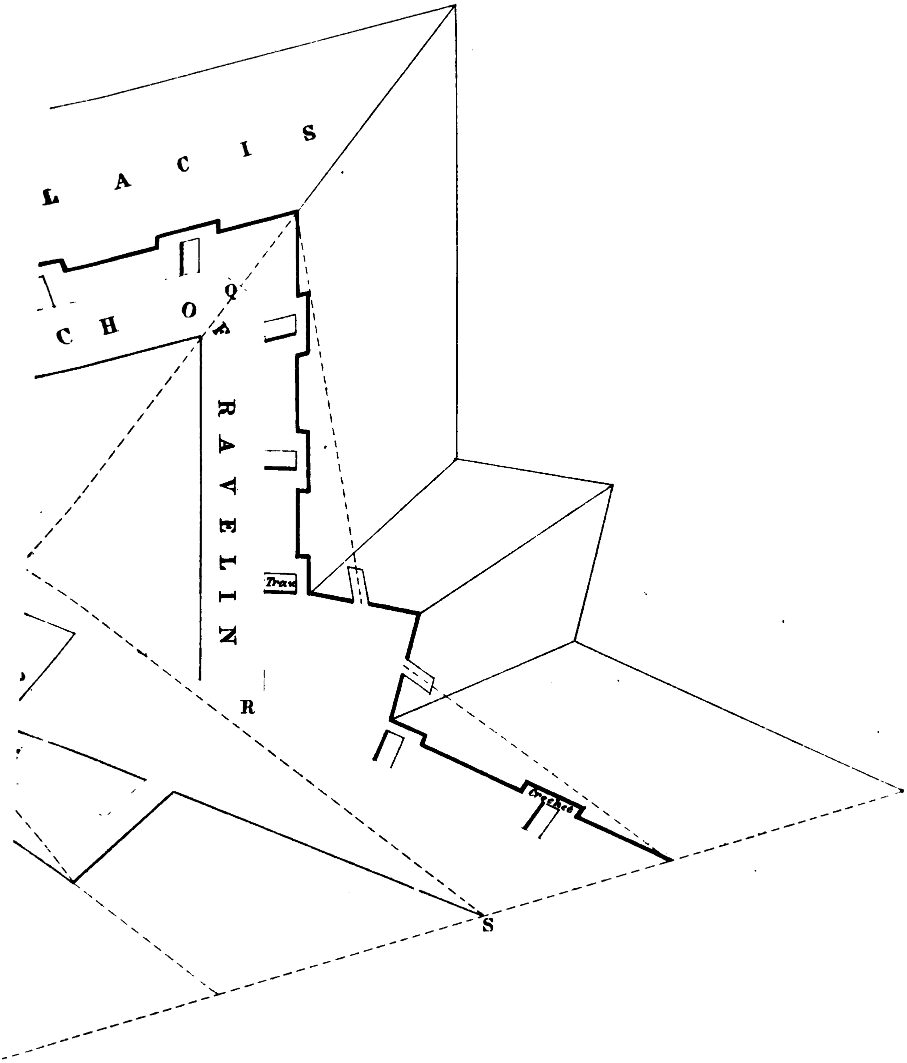


PLATE 1.

CONSTRUCTION OF THE OUTLINE ON A PENTAGON.

ENCEINTE.

CAUTION.—*Each line should be drawn exactly in the order in which it is here given.*

The Angle of the Figure is $180^\circ - \frac{360}{5}^\circ = 108^\circ$.

It is thus laid down:—Draw a perpendicular through the centre of the paper, and on each side of this line draw from the same point, at an angle of 54°—a right line of indefinite length.

The exterior sides are each made 360 yards long, measured on the lines and from the angle just found.

The perpendiculars are next drawn within the pentagon, from the centre of the exterior sides, 50 yards long.

The lines of defence are drawn from the angles of the figure through the inner extremities of the perpendiculars.

The faces of the bastions are next measured off, 103 yards, on the lines of defence, from each angle of the figure.

The flanks. With radii from the opposite angles of the figure to the extremities of the faces last found, describe arcs cutting the lines of defence—Chords to these arcs give the flanks.

The curtain is formed by joining the inner extremities of the flanks.

This completes the tracing of the magistral line of the enceinte.

☞ On this tracing we must observe—

1°. The length of the exterior side was made 360 yards, in order that the longest line of fire from the enceinte might not exceed 300 yards, the estimated range of large muskets. These, placed in the flanks to fire along the ditch, would reach the crest of the covered way in front of the salient of the opposite angle, the line of defence being 26, the ditch 30, and the covered way 10 yards.

The line of defence, 26, and the face of the bastion, 103, necessarily fix the exterior side at about 360 yards. In this particular the difference of a yard or two is insignificant.

2°. The perpendicular is 1-6th, and the face 2-7ths of the exterior side; these proportions are observed in all polygons above the hexagon.

The pentagon has its perpendicular 1-7th, the square 1-8th of the exterior side; the faces in both are 2-7ths of the exterior side.

The reason which induced Vauban to give 50 yards to the perpendicular of the pentagon, and 45 to that of the square, is the advantage gained by preserving the flanked angles above 60° and of having the flanks sufficiently large.

3°. The construction of the flanks given in the text, is that generally adopted. Vauban's flanks were slightly different, being chords of arcs described from the nearest shoulder angle of the adjacent bastion.

OUTWORKS.

Main ditch.—The counterscarp of the main ditch is traced thus:—with a radius of 30 yards for a dry, and 36 for a wet ditch, and the flanked angles of each bastion as centres, describe arcs, and draw tangents to these arcs directed towards the shoulder angles of the adjacent bastions.

Ravelin.—From the re-entering angles of the counterscarp last found, mark off on each of the perpendiculars, produced outwards, 100 yards, and from these points towards points on the faces of the adjacent bastions taken at 10 yards from their shoulder angles, draw right lines to the counterscarp of the ditch; these lines form the faces, and their intersections the salient angles of the ravelins. The ditch of each ravelin is 20 yards wide, at this distance trace the counterscarp parallel to the faces, and rounded opposite the salient by drawing an arc with a radius of 20 yards, and the salient as a centre.

Tenaille.—The faces are already drawn, being those parts of the lines of defence, or the produced faces of the bastions, which meet and form a re-entering angle at the inner extremities of the perpendiculars. Parallel to the faces, and 16 yards in the rear, draw the gorges; the extremities are drawn parallel to the flanks, at a distance of 8 yards, forming the openings called trous de tenaille or gaps of tenaille.

Caponniere —Draw the crest lines on each side of the perpendicular parallel to it, and at a distance of 6 yards. The head of each half caponniere must be drawn parallel to the adjacent demigorge of the ravelin at a distance of 3 yards. The foot of the glacis is drawn parallel to the crest lines at a distance of 20 yards.

Covered way.—To trace the covered way, draw parallels to the counterscarp of the ditches, 10 yards distant; these are the crest lines of the covered way. The foot of the glacis is drawn parallel to the crest lines, at a distance of 50 yards.

Re-entering place of arms.—Mark off on each side of the re-entering angles, formed by the crest lines of the covered way, 30 yards, these are the demigorges. Right lines from the points just found, making an angle of 100° with the crest of the covered way, and forming a salient angle, are the faces.

Sally Ports.—Bisect the faces of the re-entering places of arms, and from the points of bisection draw lines towards the salient angles of the adjacent salient places of arms; these lines give the direction of the sally ports, the entrances of which are thus well flanked from the adjacent branches of the covered way, and are not exposed to a direct fire from any part of the country. Lines drawn parallel to this line of direction, on each side of it, at the distance of 2 yards, and 8 yards in length from the crest, form the the two sides.

Traverses are 10 yards long, the width of the covered way. In an outline the superior slope only is marked, by the crest line and exterior side, at the usual width of 6 yards.

The traverses at the salient places of arms are placed so that the exterior sides coincide with the faces of the bastions and ravelins produced. Those at the re-entering places of arms have their crests drawn from the extremities of the faces of the re-enteringc places of arms, perpendicular to the counterscarp.

On each branch of the covered way, opposite the faces of the ravelins, a third traverse is placed perpendicular to the counterscarp, and midway between the traverse at the salient and that at the re-entering place of arms.

Crochets.—The passages round the ends of the traverses, called crochets, are 3 yards wide in the clear, and consequently in an outline the crochet is made wider on the crest side of a traverse than on the exterior side, because on the crest side, the interior slope, banquette, and slope of banquette are omitted and on the exterior side, only the exterior slope is omitted.

To trace the crest of the crochets, draw lines parallel to the head of each traverse at a distance of 11 feet, and parallel to the crest and exterior sides of each traverse, at the respective distances of 23½ and 16 feet.

Recapitulation of the Lines and Angles on a Front of Fortification. The letters refer to the Outline, Plate 1.

A B	Exterior side.	A I G H K B	Magistral, or Cordon, or Outline.
E F	Perpendicular.		
G B	Line of Defence.	C D	Interior side.
A I	Face of the Bastion.	T A	Great, or Oblique, or Exterior Radius.
G I	Flank of ditto.		
G H	Curtain.	T E	Right Radius.
C G	Demigorge.	T C	Small or interior radius.
A C	Capital.		
O P Q R	Counterscarp.	C	Centre of the bastion.

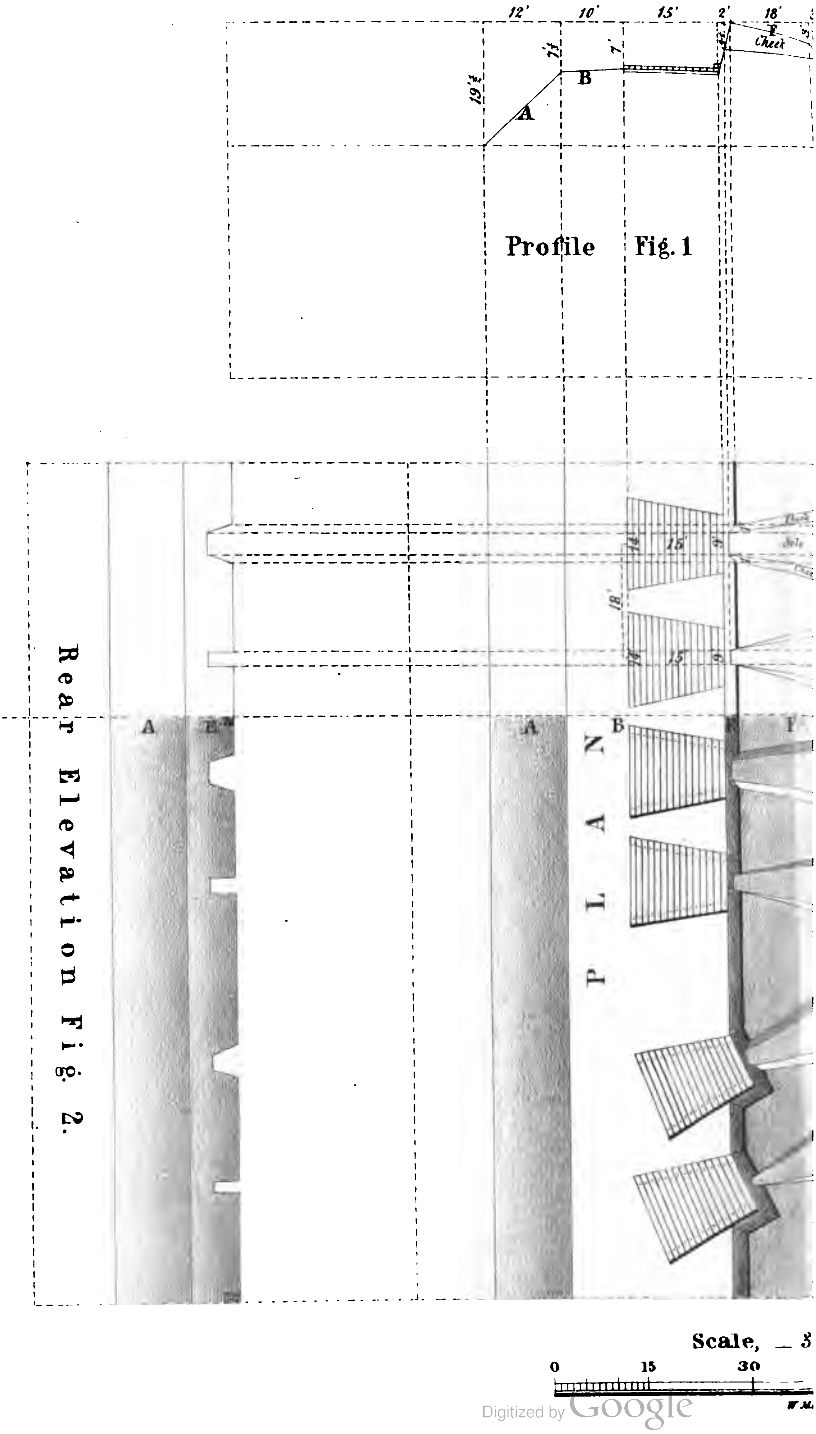
A B R	Angle of the figure	A F B	Angle of Tenaille, or Flanking Angle.
K B L	Flanked Angle.		
E A F	Diminished angle.	G H I	Interior Flanking Angle.
A I G	Shoulder Angle.		
I G H	Curtain Angle, or Angle of the Flank.	O P Q	Re-entering Angle of the Counterscarp.
I G F	Angle of Defence.		

Table of the principal Linear and Angular dimensions on a Front of Vauban's First System, arranged for figures of 4, 5, 6, 7, or 8 sides.

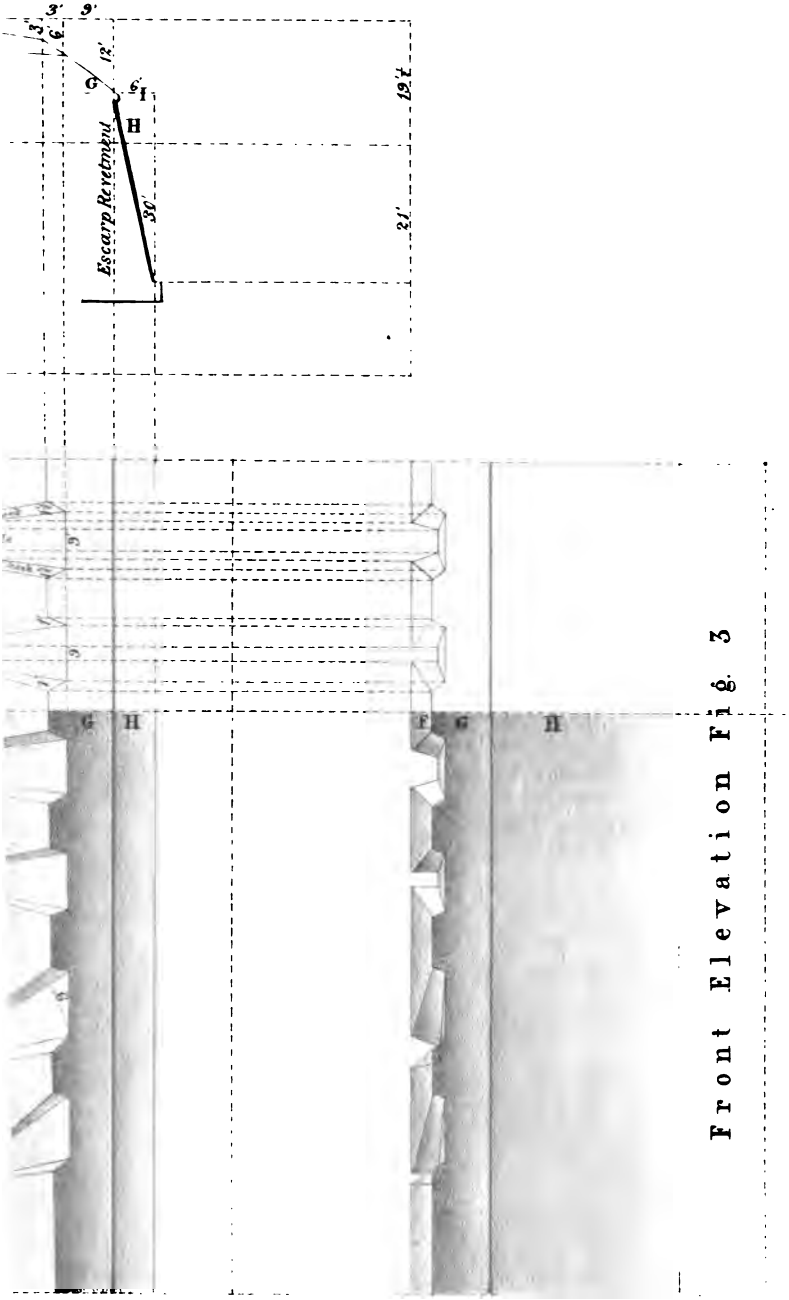
No. of sides	4	5	6	7	8
Exterior side	360	360	360	360	360
Perpendicular	45	50	60	60	60
Line of defence	260	260	262	262	262
Face of the Bastion	103	103	103	103	103
Flank of ditto	36	44	54	54	54
Curtain	114	142	140	140	140
Demigorge	44	40	60	68	74
Capital	88	86	96	92	90
Great Radius	254	306	360	413	469
Small Radius	165	219	283	321	378
Angle of the figure	90°	108°	120°	128°35′	134°15′
Flanked Angle	62°	76°	83°	92°	98°
Shoulder Angle	110°32′	114°	127°	121°	121°
Curtain Angle	98°	102°	102°	102°	102°
Angle of Tenaille	151°	148°	143°	143°	143°

Note. The dimensions above are not the exact proportions laid down by Vauban, but are close approximations, correct enough to be employed in constructing detached portions of the First System, as in Plates 3 and 4.

PLAN, PROFILE & GEOMETRICAL E



ELEVATIONS OF EMBRASURES.



Front Elevation Fig 3

0 Feet to an Inch.

45 60 75 90

khouse Lith York

PLATE 2.

PLAN, PROFILE, AND GEOMETRICAL ELEVATIONS OF EMBRASURES.

PLAN.

This drawing in outline, without shading or colour, would represent a horizontal plane cut through the soles of the embrasures, and be in the strictest sense a plan. The outline when shaded and coloured, is still improperly called a plan or plane: it is really a *map* or *projection,* because the elevation and depression of the slopes are shewn.

The inner extremity of an embrasure is called the *neck,* and is 2 or 3 feet wide; the outer opening is called the *mouth,* its proper width is half the thickness of the parapet, usually 9 feet. The sides are called *cheeks,* these at the neck are frequently vertical, that the men working the guns may be better protected. The cheeks of an embrasure decline outwards from the neck to the mouth. At the neck their planes are either vertical or have a declination of 1 foot; at the mouth their planes decline 1 foot, or 1½ feet. Two instances of each kind of embrasure are drawn in the plan.

The lower surface of an embrasure is called the *sole,* and is 2 feet 6 inches above the platform on which the gun is placed. The plane of this sole is horizontal or inclined according to the position of the object to be fired at.

Generally the axis of an embrasure is perpendicular to the crest of the parapet, but in the flanks of a bastion, and in some other cases, the embrasures are cut obliquely, all the dimensions however, are still set out perpendicular to the axis of the embrasure.

Embrasures are cut 18 feet apart, measuring from centre to centre.

The usual dimensions of the platform are those given in the plan.

FIGURE 1.

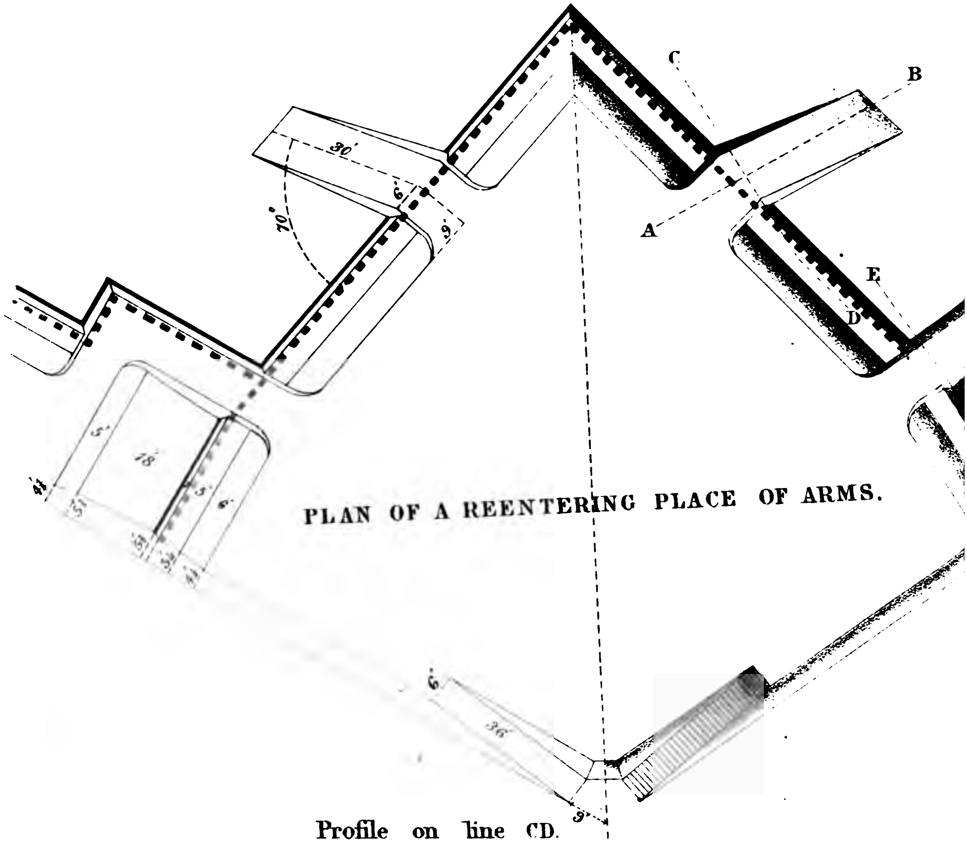
By producing upwards the lines which mark the thickness of the different slopes and the length of the platform, &c, in the plan, and by drawing at right angles the planes of site and defilade, we obtain a profile, or an orthographic section of an embrasure in the face of a bastion or ravelin. It represents the parapet as cut perpendicularly through the sole of the embrasure to the base of the revetment, and shews the thickness, height, and depth of the several parts of the embrasure and rampart.

FIGURES 2 and 3.

Similarly by producing lines right and left, as indicated by the dotted lines, we obtain the front and rear geometrical elevations, in which all the parts seen respectively in front and rear are represented in their proper proportions.

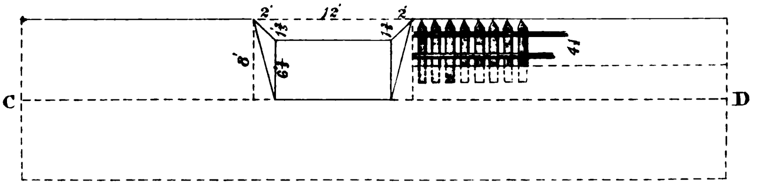
Explanation of the letters of reference in plan, profile, and elevations.

A H	Rampart.
A	Interior slope of rampart.
B	Terre-plein of rampart.
C D	Banquette.
C	Slope of banquette.
D	Terre-plein of banquette.
C G	Parapet.
E	Interior slope of parapet.
F	Superior slope of parapet.
G	Exterior ditto ditto.
H	Exterior slope of rampart, or the Escarp.
I	Cordon.
L	Revetment.
M	Counterfort.

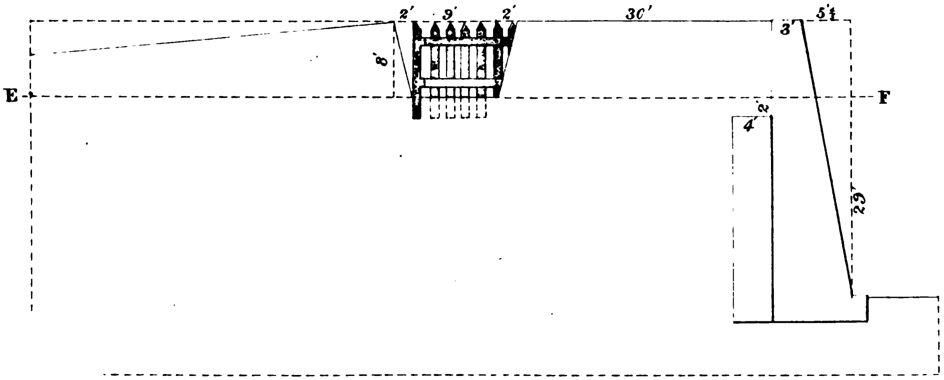


PLAN OF A REENTERING PLACE OF ARMS.

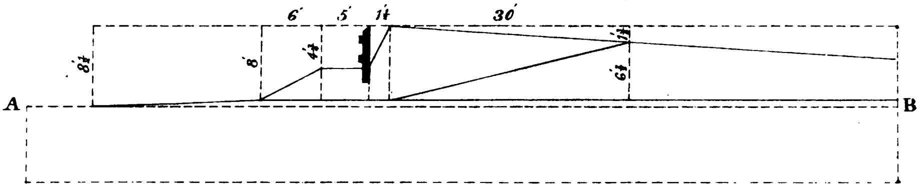
Profile on line CD.

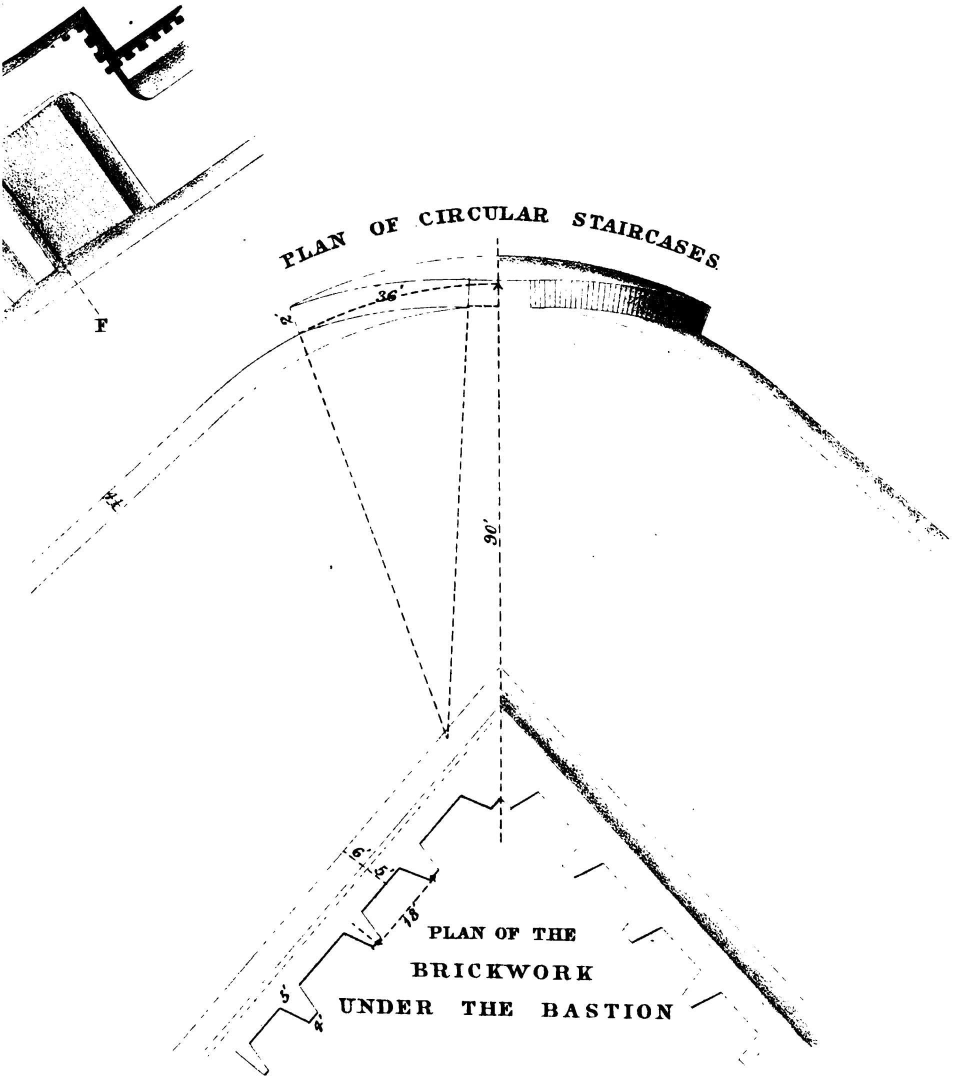


Profile on line EF.

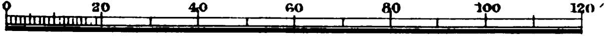


Profile on line AB.

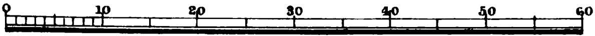




Scale for Plans,_ *40 Feet to an Inch.*



Scale for Profiles,_ *20 Feet to an Inch.*



W. Monkhouse, Lith. York

PLATE 3.

PLAN OF A RE-ENTERING PLACE OF ARMS.

CAUTION.—*Each line should be drawn exactly in the the order in which it is here given.*

First set off the re-entering angle of the counterscarp, 115° for a pentagon, 120° for a hexagon, and draw the gorges and the outline of the faces and traverses as previously described. *Vide Re-entering place of arms, page* 11.

The lines of direction, *vide Sally ports*, page 11, may be set off, lightly in pencil to be afterwards rubbed out, at about 70°.

☞ The horizontal width of any slope as measured on a plane, is called the base of that slope, because it is the base of a right angled triangle, the perpendicular to which base gives the height of the slope.

The outline being completed as above, these slopes named below, are to be drawn within the crest of each face, traverse, and branch of the covered way. The base of each is—

Interior slope	1½ feet.
Banquette	5 do.
Slope of do.	6 do.

The exterior slope of each traverse has a base of 5 feet, the interior slope of each crotchet 2 feet. The turf revetments at the head of each traverse and on the sides of the sally ports, have a slope one fourth of their height. *Vide note on profiles Caponniere*, page 23.

The inner end of each traverse is brickwork, built up in continuation of the counterscarp revetment, with a slope of one fifth of its height.

Staircases, also called *pas-de-souris.*—The sides of the re-entering angle first drawn, represent the top of the counterscarp revetment. Draw parallels to these lines, below them and at a distance of 4½ feet, to represent the base of the revetment.

To trace the staircases, mark off 9 feet on each side of the re-entering angle made by the base of the counterscarp wall just found, and, with a radius of 36 feet, from these points as centres, draw arcs to intersect the top of the counterscarp wall; chords to these arcs form the outer sides of the staircases.

The pallisades which run along the banquette and round the crochets, are 9 inches broad, with their flat sides inwards, and stand 9 inches apart.

The openings into the re-entering place of arms by the sally ports and at the heads of the two traverses, are closed by strong gates represented in the plan by a continuation of the pallisades.

PLAN OF THE CIRCULAR STAIRCASES IN THE FRONT OF A BASTION.

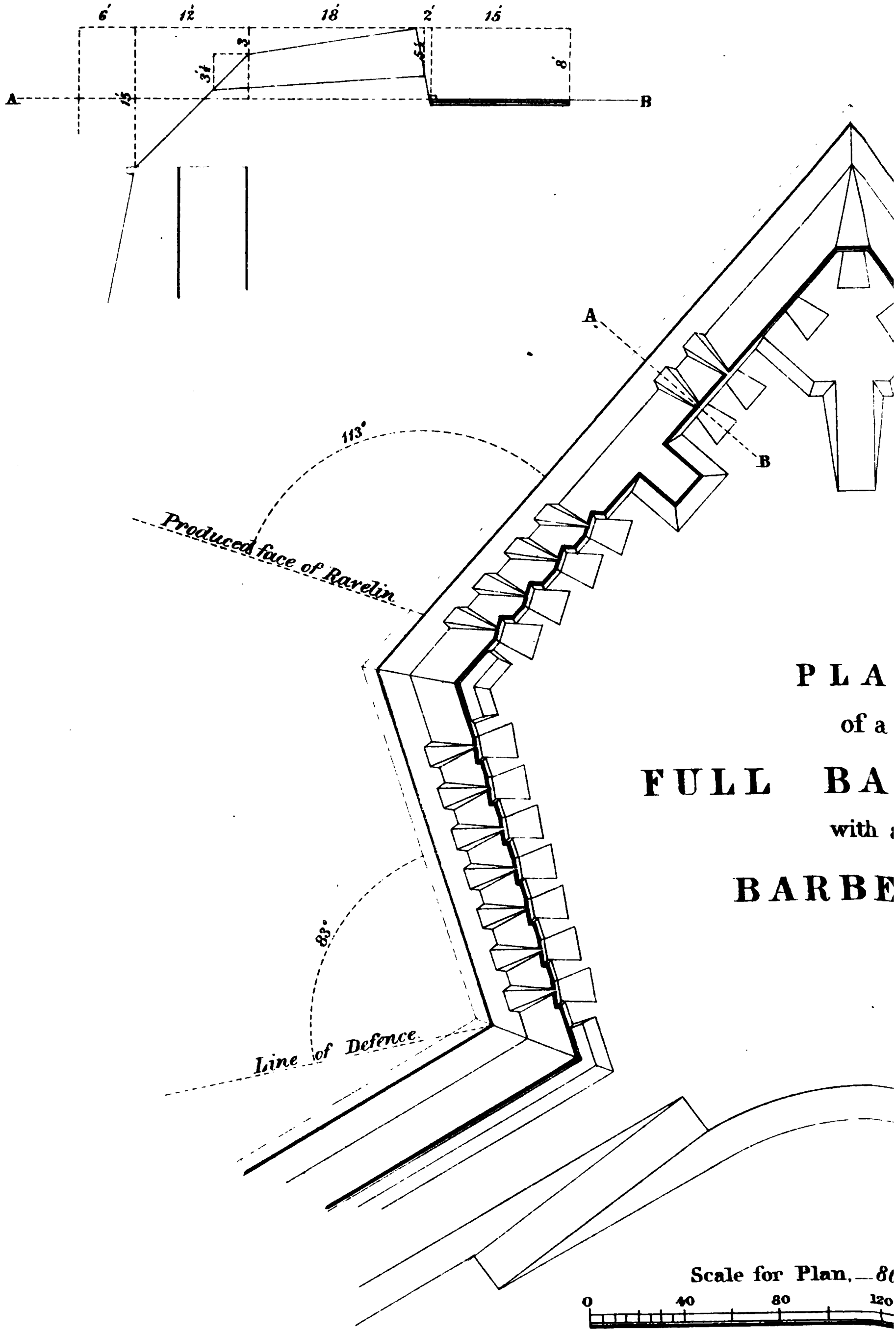
Caution.—*Each line should be drawn exactly in the order in which it is here given.*

Draw from the salient of the cordon of the bastion, as a centre, concentric arcs 4 feet and 1-5th apart, to represent the top and bottom of the counterscarp wall, and let the radius of the outer arc be 30 yards, the width of the main ditch.

Let the Capital of the bastion be produced upwards, and on each side of this line proceed as follows.

At a distance of 6 feet from it, take a point in the base of the counterscarp wall, and with this point, as one centre, and

Profile on line AB.



PLA

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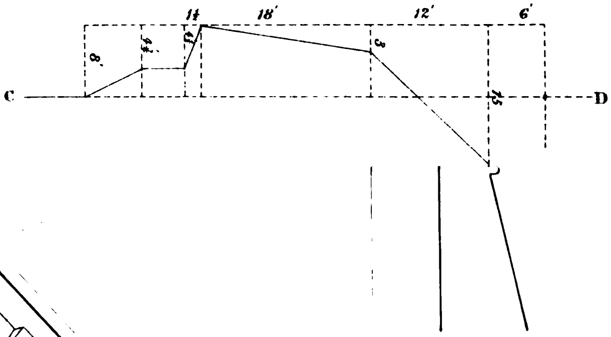
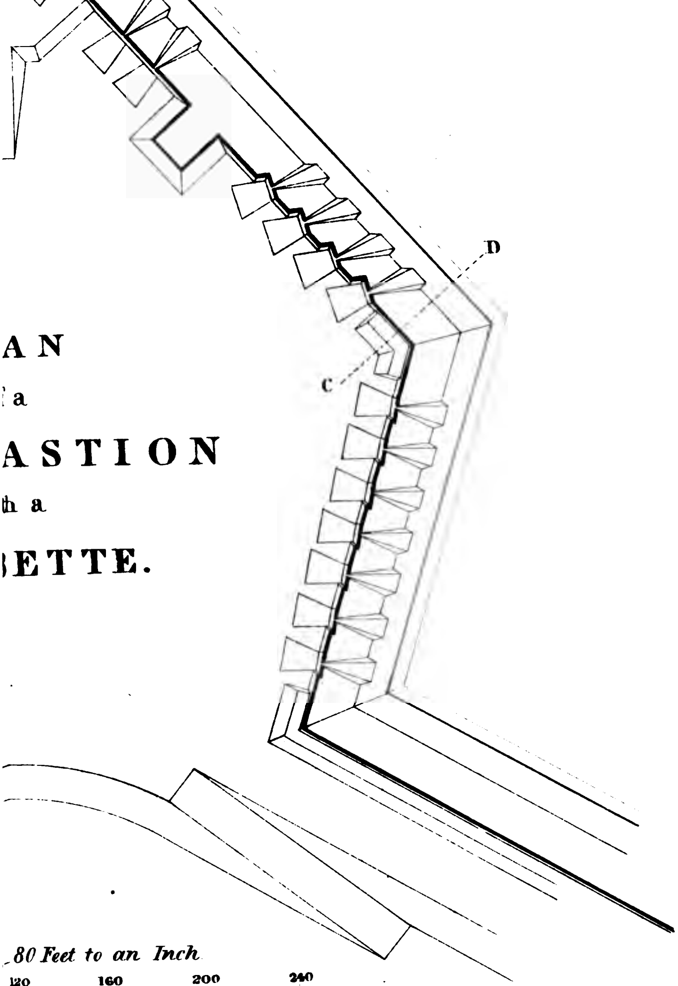
with

BARBE

Plate 4.

Profile on line C D.





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80 Feet to an Inch

20 Feet to an Inch

use, Lith. York.

36 feet as a radius, describe an arc intersecting the top of the counterscarp wall, and let this point of intersection form a second centre.

From these two centres, and with a radius of 30 yards, describe arcs towards the salient of the bastion, these arcs will intersect, and let this point of intersection be a third centre.

With the same radius of 30 yards, describe from this third centre, an arc extending from the first to the second centre. This line represents the outer edge of one staircase; and an outer concentric arc, described 6 feet from it, represents the inner edge. Each step should be drawn towards the centre of these two arcs.

The circular staircase on each side having been thus drawn, the innermost edges of the top steps of each staircase, and the innermost edges of the bottom steps of each staircase are successively joined by arcs drawn from the salient of the bastion, as a centre.

PLATE 4.

PLAN OF A BASTION WITH A BARBETTE BATTERY.

The salient, shoulder, and curtain angles, and the lengths of the faces and flanks are given in the table, page 13.

First describe the outline of the bastion with these dimensions and add the slopes as given for the enciente, page 21-2, then trace the lines of defence lightly in pencil, to be rubbed out after the embrasures in the flanks are drawn.

The embrasures and the platforms are all of the dimensions given in plate 2.

☞ In this bastion the interior slope of the parapet is represented as serrated, which arrangement allows the guns to be pushed further through the embrasures. In a front drawn on a scale of 30 yards to an inch, as the dimensions are so very minute, the pupil is scarcely ever expected to trace the embrasures and platforms absolutely correct, as in this drawing: hence the advantage of drawing the first system in detail on a larger scale, as in plates 2, 3, and 4,

The axes of the embrasures are thus laid down:—

Each flank is 54 yards long, which gives space sufficient for 7 guns placed 6 yards apart.

Take a point on the crest 9 yards distant from either the shoulder or curtain angle, and from this point measure off 6 spaces of 6 yards each.

Seven points will be thus obtained, through which draw the axes of the embrasures parallel to the line of defence.

Ten yards from each shoulder angle mark lightly in pencil, to be afterwards rubbed out, the lines representing the produced faces of the ravelin, parallel to these lines are to be drawn the axes of the four embrasures, the guns in which flank the ditch of the ravelin.

From a point on the cordon, 1 yard distant from the lines just drawn, and towards the salient, take 3 spaces of 6 yards each, and through these four points draw the axes in the direction just named.

The Barbette.—From the salient of the crest, and on each side of it, mark off 60 feet, and at these points trace perpendiculars to the crest 30 feet long; on the line joining the extremities of these perpendiculars, construct the ramp, and add the slopes according to the dimensions marked in the plan.

Cut off the salient of the crest by a crest line 5 yards long, before drawing the platforms.

The space on each face between the barbette and the nearest platform of the battery flanking the ditch of the ravelin, is proportionately divided between a ball-proof traverse and two guns.

Plate 5.

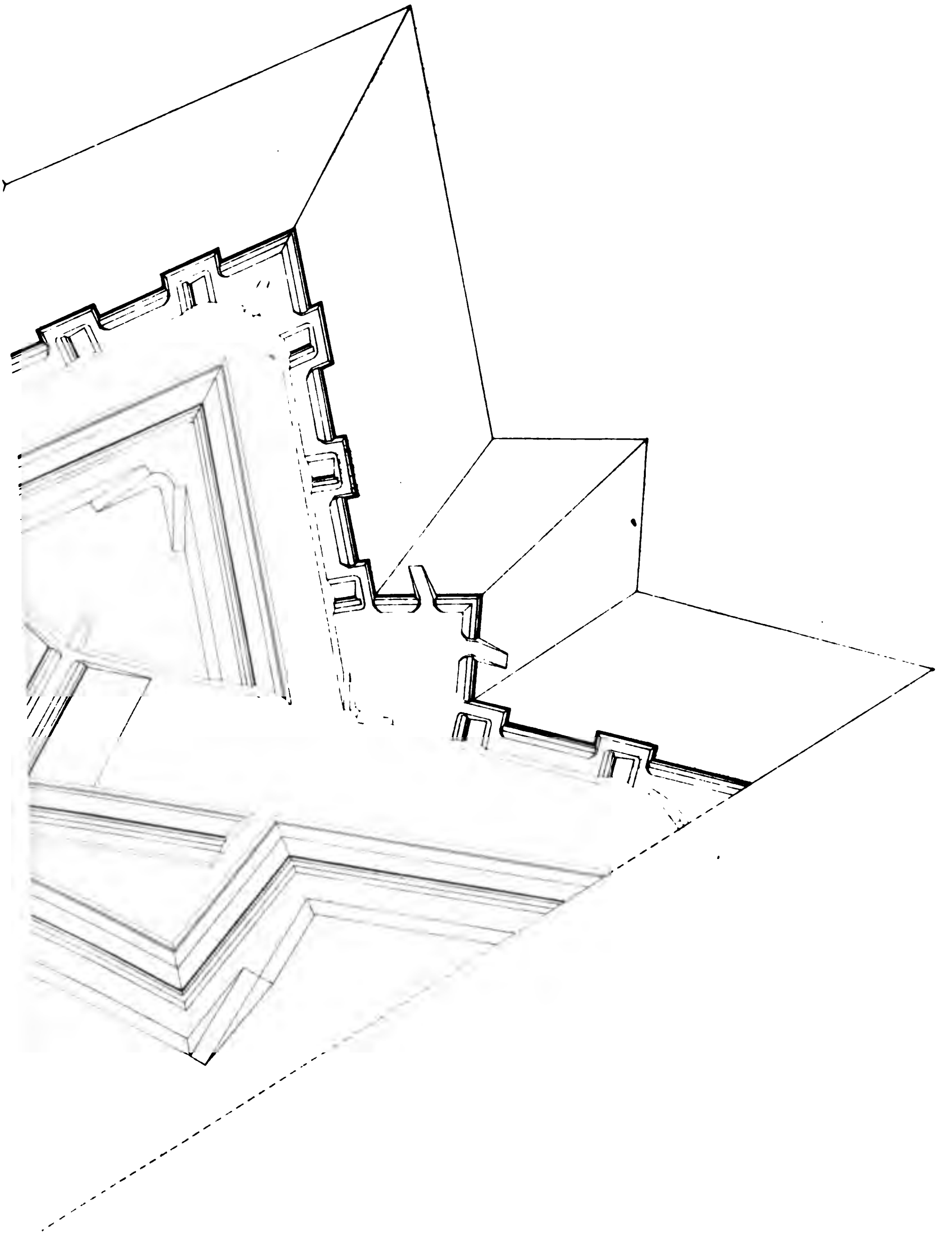


PLATE 5.

VAUBAN'S FIRST SYSTEM.

CAUTION.—*All the dotted lines in this drawing are required for the construction of the plan, and they have been retained for the convenience of the student. After having completed the plan in pencil, he will observe that none of the dotted lines in the plate are to be inked over in his drawings. The only exceptions we recommend, are the exterior side,* A B, *and the perpendicular,* B C.

First trace the outline in pencil, as described in the instructions to plate 1. If, however, the figure chosen be a hexagon, and the scale 30 to an inch, as in plate 5, proceed as follows :—

Obtain the angle in the same manner as the angle of the pentagon was obtained, and then, instead of using compasses to take off the exterior sides and perpendiculars, place the ordinary 12 inch scale on its edge, with one extremity on the angle of the figure and mark off with a pencil, 12 inches, for the exterior side, without removing the scale, take the centre at 6 inches, and from it mark off the perpendicular 2 inches. In this way a considerable part of the outline may be drawn, without making a single puncture with the compasses, which an unskilful, that is to say an unpractised hand, should avoid whenever it can be conveniently done.

The outline being fully drawn, add the slopes in the following order. The slopes of the revetments are drawn in front of the cordon, all the other slopes are within it. Their horizontal dimensions are—

ENCEINTE.

Slope of the Revetment	6	feet.
Exterior slope of parapet	12	do.
Superior ditto	18	do.

Interior ditto	1½	do.
Tread of banquette	4½	do.
Slope of ditto	6	do.
Terre-pleine of rampart	24	do.
Slope of ditto ditto	14	do.

The ramps at the gorge of the full, and flanks of the empty bastions, leading from the town to the ramparts may be made 34 yards long and 6 yards wide.

RAVELIN.

Slope of the escarp revetment	6	feet.
Exterior slope of the parapet	9	do.
Superior ditto	18	do.
Interior ditto	1½	do.
Tread or step of banquette	4½	do.
Slope of ditto	6	do.
Terre-pleine of rampart	18	do.
Interior slope of ditto	11	do.
Slope of the counterscarp revetment drawn in front of each demigorge	3	4-5ths

The ramps leading from the body of the ravelin to the terre-pleine may be made 20 or 24 yards long and 4 yards wide. The extremities of the faces are built up in continuation of the counterscarp revetment. The rampart is, therefore, seen in profile, and the width of each part should be one fifth of its height. The staircases at the re-entering angle made by the gorge revetment, is 36 feet long and 6 feet wide.

TENAILLE.

Slope of the escarp revetment	3	feet.
Exterior slope of parapet	6	do.
Superior ditto	18	do.
Interior ditto	1½	do.
Step of banquette	4½	do.
Slope of ditto	6	do.
Slope of counterscarp revetment drawn in front of each demigorge	3	1-5th

The staircases at the gorge are 30 feet long and 6 feet wide. The profiles of the extremities are drawn like those of the ravelin.

CAPONNIERE.

Interior slope	1½	feet.
Terre-pleine of banquette	5	do.
Slope of ditto	6	do.

The profile at the head of each half caponniere is drawn with a width of 2 feet from the crest to the base of the parapet, one fourth of its height as near as practicable.

☞ Here we may remark that the profiles at the head of each caponniere, and in fact all the profiles in plate 5, may be copied without measurement, as exaggeration is unavoidable even with the greatest care. All that can be reasonably wished for, in this particular, is the absence of any very evident misproportion.

COVERED WAY.

The covered way may be completed from the instructions given for constructing the re-entering place of arms, plate 3.

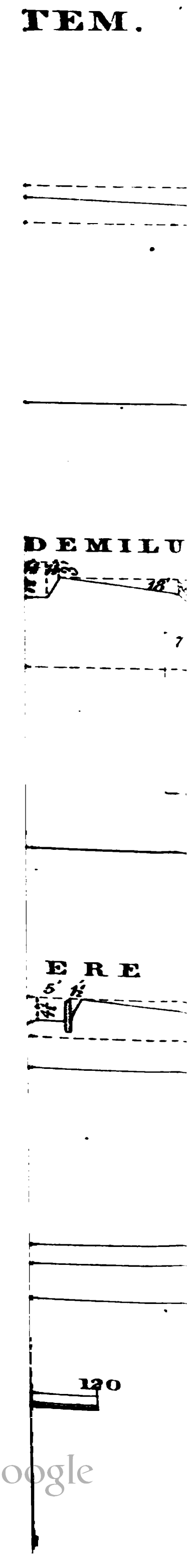
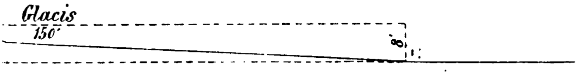
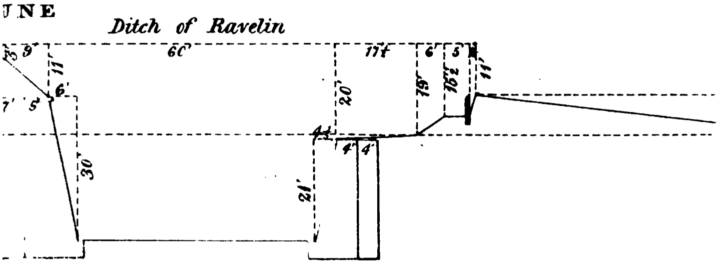
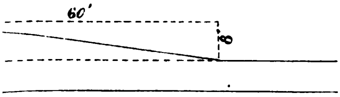

TEM.
DEMILU
18'
7
ERE
5'
120

Plate 6.


Glacis
150'
8'


JNE
Ditch of Ravelin
11½'
10½'
4½


60'
8'

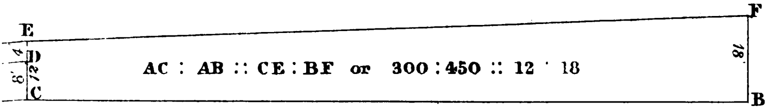

E
F
D
C
B
4
12
8'
18
AC : AB :: CE : BF or 300 : 450 :: 12 : 18

PLATE 6.

PROFILES TO THE FIRST SYSTEM.

Draw the lines representing the plane of defilement, and the ground plane or plane of site, parallel to each other, and 22 feet apart.

Trace lines to represent the bottom of each ditch parallel to the line of site, and 22 feet below it. Mark off, on the line of defilade, the horizontal width of every slope; by the figures given in the plate, or from the horizontal dimensions given in the instructions to plate 5. Let fall perpendiculars from these points to the line of site, and mark the vertical height of each slope as in the drawing.

The vertical elevation of one work above another, or above the country, is termed command.

It will be evident, after a brief examination of plate 6, that—

	feet.
The command of the enceinte over the country, is	22
Ditto ditto over the crest of the ravelin	3
Ditto ditto over the glacis	14
Ditto ditto over the tenaille	20
Ditto of the ravelin over the crest of the glacis	11
The crest of the glacis above the ground	8
The depth of the main ditch, and the ditch of the ravelin below the ground plane	22

☞ The above list of the various commands, together with the recapitulation on pages 12 and 13, and the explanation of references on page 16, are pointed out to the beginner as some of the very first things with which he should make himself familiar.

Every other information that is requisite and that could be given in the plate has been inserted, all needed here is an explanation of the diagram for determining the command of the enceinte over the country.

MODE OF DETERMINING THE COMMAND OF THE BODY OF THE PLACE.

1°. Let A B equal 450 feet, the horizontal distance from the enemy's third parallel, at the foot of the glacis, near the salient of the ravelin, to the genouillere of the embrasure on the face of the bastion.

2°. Let A C equal 300 feet, the horizontal distance from the same point of fire, to the crest of the covered way.

3°. Let C D equal 8 feet, the height of the crest of the covered way, and add to this 4 feet, making C E equal to 12 feet.

Then by similar triangles

A C : A B : : C E : B F or 300 : 450 : : 12 : 18

which gives the height of the muzzle of a gun on the face of a bastion, the shot of which passes 4 feet above the crest of the covered way. To 18 feet add 4½ feet for the height of the crest of the parapet above the muzzle of the gun, which gives a total of 22 feet 6 inches, for which 22 feet is usually substituted, as in the diagram.

☞ Every student should produce approved drawings of the outline and of the succeeding plates of details, before he proceeds to a complete drawing of the First System, with all the slopes traced as in plate 5. The plan should be completed without the insertion of any embrasures or platforms, or even the barbettes in the salients of the bastions and ravelins. He may then undertake, on a scale of 30 yds. to an inch, a complete drawing of the First System, with the embrasures and barbettes in the bastions, according to plate 4. The crest of the parapet may be made serrated, as in plate 4, or straight, according to the skill of the draughtsman. The barbettes in the ravelins are the same as those in the bastions, except that the perpendicular is 24 instead of 30 feet, and the rampart is shorter.

The space remaining on each face of the ravelin after the construction of the barbette, is proportionately divided between two ball proof traverses and four guns. Further details, it is hoped, are unnecessary to any one who has traced and understood all that has been described in the preceding pages.

Should any insuperable difficulty occur to the student in attempting to draw a complete plan of the First System, a supplementary plate may be had of the publisher. With this assistance, no further doubt can exist, but it should not be applied to at first. It can only be legitimately used to test the correctness of what has been done, and ought never to be tolerated as a copy to work by.

This drawing is on a scale of 30 yds. to an inch, and besides being a complete plan of Vauban's First System, it contains the geometrical elevation of the enceinte.

It is intended for as perfect a specimen of shading and colour as can, under the most favourable circumstances, be produced by students in our military schools and colleges.

Unless, however, the pupil has had considerable experience in water colour painting, we do not recommend him to attempt, with-the immediate superintendance of a master, to colour any of his drawings. A drawing neatly traced, is very little, perhaps not at all improved, if ever so well shaded and coloured, but high and glaring colours spoil the best drawings.

The First System with the embrasures, barbettes, and elevation traced and fully shaded and coloured as in the supplementary plate, can only be properly executed by the most accomplished draughtsman.

REMARKS ON PLAN-DRAWING, COLOURING AND SHADING.

No harder pencil than a three H should be used.

Trace all the works in pencil before any part of the drawing is inked in. This rule ought in every case to be strictly adhered to, as it will prevent the frequent occurrence of erasures, which too often mar the beauty of the most elaborate productions. When an erasure is unavoidable, perhaps the best way of effecting it neatly, is to make use of very fine glass paper.

The scales, should not be made shorter than 6 inches. The lettering, and the title should be executed in the simplest style, without flourishes, or ornament of any description.

It is usual to represent all the masonry work in red lines, and the earthen work in black.

The cordon or magistral line of the enceinte, the faces of the ravelins, tenailles &c., are therefore drawn in thick lines of carmine, if the rampart is revetted with masonry; and in thick lines of Indian ink, if the revetment is of turf.

The crests of the parapets, both of the enceinte and covered way, are thick black lines. The lines marking the terre-pleine and slopes of all the works should be very fine and black. The line marking the foot of the glacis should be the thinnest in the drawing, some French draughtsmen do not trace it at all.

The thickness of the principal or cordon, by which that of all the other lines is graduated, should be in proportion to the size of the drawing.

The colours necessary for plan-drawing, are Indian ink, carmine or lake, burnt sienna or light red, Prussian blue or indigo, and gamboge.

Indian ink is employed to show the different slopes of earthwork, and to mark the shadows All the slopes should be shaded downwards from the top, lighter towards the bottom. Begin with a light shade and darken it gradually by repetition. To obtain a deep and very smooth shade, perhaps seven or eight coatings will be required.

The *terre-pleine* of the works are not generally coloured; sometimes, however, a light tint of Indian ink is passed over them, to distinguish their level from that of the ground plane.

In fixing upon a place from which the light shall fall, the upper left hand corner is generally chosen, and all slopes that face it are but slightly shaded, while those on the opposite side are made darker.

Be careful to finish all the Indian ink shading before painting the ditch or revetments, and the thick lines, both black and red, should not be drawn until the shading and painting is finished, otherwise they will not preserve their proper depth and distinctness.

Indian ink for shading, should be fresh rubbed up every day. For tracing lines and for lettering, always rub the ink till it is perfectly black, as brown lines and letters never look well.

Carmine is used for revetment walls and all the masonry work. The profiles of masonry are covered with a flat tint of carmine very light, the counterfort should be represented a little lighter than the revetment. A thick red line is drawn on the sides of the revetments and counterforts which are farthest removed from the light.

Burnt sienna is used for a dry ditch, which should be coloured with a light flat shade. A small admixture of carmine (I think) greatly improves the tint. The profiles of ramparts are also shaded with burnt sienna. It is a gritty colour, and should be prepared in a deep vessel, so that the brush may not touch the bottom and take up the sediment.

Prussian Blue: A wet ditch is represented by a light blue tint, shaded from the edges lighter towards the middle.

Gamboge for all kinds of wood work. Some object to the use of gamboge in drawings where many platforms are introduced, because it produces too glaring an effect, and recommend a light shade of yellow ochre.

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